EFFECT OF TOWN WASTE-WATER ON THE DEVELOPMENT OF CILIATA PLANKTON IN THE SZOLNOK SECTION OF THE TISZA

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Abstract

The results are reported of hydrobiological examinations carried out in 1958, 1962 and 1970 in the Szolnok section of the Tisza. The aim of the investigations was to establish how and to what extent the town waste-water effects the development of the Ciliata plankton in the river. The water of the Tisza arriving at Szolnok can be classified as first-quality. The Szolnok section of the river is polluted not only by the waste-water, but also by the by-products of various industrial works. Of these, the paper and cellulose, sugar and chemical factories have significant effects. Water samples were taken below the waste-water inlets. The inflow of the water of the river Zagyva results in a 50% concentration change in the Tisza. On average, the total dry matter content of the Tisza water is 200 mg/l more below the confluence than above it. As a consequence of the concentration change, the Ciliata plankton is almost completely destroyed below the mouth of the Zagyva. The development of the number of Ciliata plankton species and their frequencies are illustrated graphically. Those species which were found in the water samples on at least 2 occasions during the examination periods are tabulated. 7 of the 27 species are α-meso and polysaprobiotic species. The data from the investigations confirm that below the main sewer inlet from the town, and the waste-water inlets from the cellulose and sugar factories, the river assumes an α-meso and polysaprobiotic character. Because of the toxic effect of the industrial waste-waters, the numbers of species and individuals among the Ciliata plankton are generally low.

Collection sites and examination methods

It is clear from the literature that the study of the pollution of natural surface waters is being increasingly supplemented by biological examinations. The practical importance of these latter arises from the recognition of the fact that the polluted or unpolluted nature of natural surface waters is indicated by the biological state of the waters.

In the biological examination of surface waters the quantity and quality of the indicator organisms are taken as basis for the demonstration and depicting of the pollution (HUSMANN 1948—49, KNÖPP 1954, LIEBMANN 1964). The frequencies of organisms of the same saprobity are determined at each of the collection sites. In this way numerical values are obtained to express the degree of each saprobia. With the aid of the numerical values, the extent of pollution of the water is plotted graphically by various methods. The pollution of the Danube was studied by a similar method by MUHITS (1955).

The experience of the present author has convinced him that the members of the Ciliata plankton react sensitively to changes in their environment. Since the Szolnok section of the Tisza serves as a classic example for the examination of the effects of various town waste-waters, the aim of this investigation was chosen to be the establishment of how and to what extent the town waste-waters affect the development of the Ciliata plankton in the Szolnok section of the Tisza.

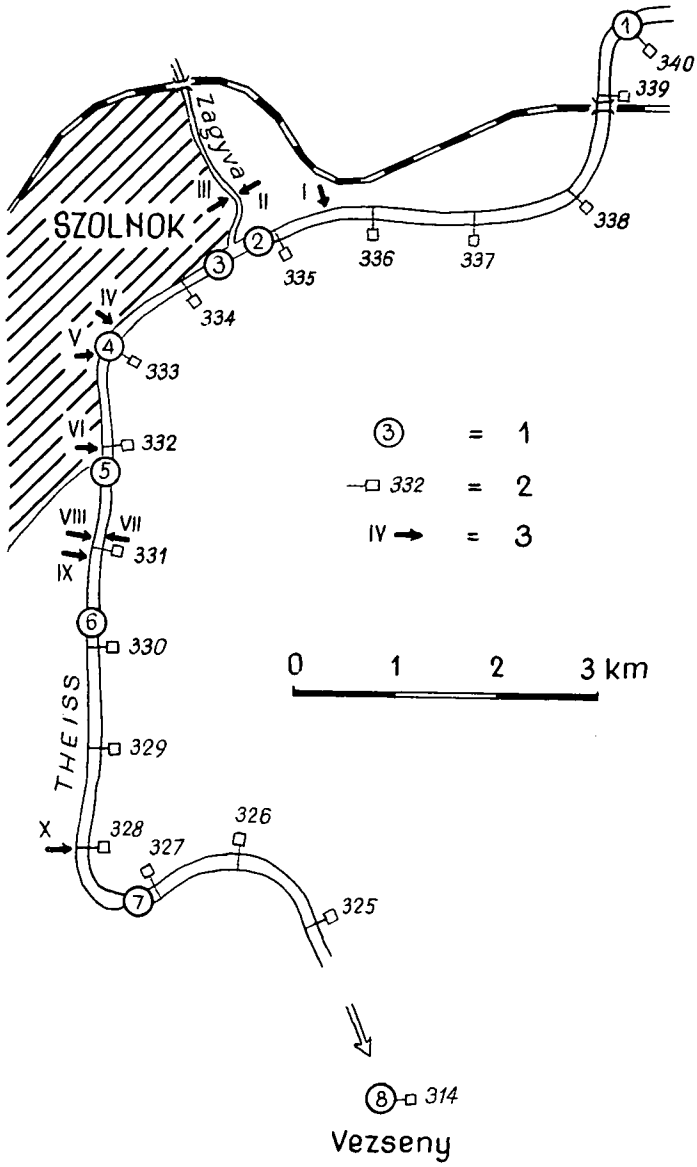

Fig. 1. Waste-water inlets into the Tisza at Szolnok and the collection sites in the Szolnok section of the river.
1 = collection sites
2 = river km
3 = waste-water inlet sewer

In the interest of the study of the effect of the town waste-waters, the water samples were primarily taken below the waste-water inlets: at 334.5 river km, above the mouth of the Zagyva, at 334 river km, below the mouth of the Zagyva, at 333.5 river km, below the main town sewer inlet, at 332 river km, below the paper and cellulose factory waste-water inlet, at 331 river km, below the sugar factory waste-water inlet, and at 327 river km, below the chemical factory waste-water inlet. Water samples for control examinations were taken at 340 river km, 5 km above the town, and at 314 river km, 20 km below the town, at Vezseny. The town waste-water inlets and the collection sites are shown in Fig. 1. The water samples were mainly taken at distances of 5 and 10 m from the bank, for the Ciliata plankton tend to form associations close to the banks of the river. The plankton examinations were based on a total of 90 water samples: 36 were taken in 1958, 24 in 1962, and 30 in 1970. In every sampling a plankton net (no. 25) was used, and 100 litre water samples were filtered. For the study of the town pollution, water samples were mainly taken from the right bank. On the left bank, corresponding to the pollution collections were made above and below the mouth of the Zagyva and at 331 river km.

The individual species were determined on the basis of the book by KAHL (1935). The determinations involved the use of sublimate fixation, and the GELEI—HORVÁTH silvering, the PÁRDUCZ rapid staining, the BRESSLAU opal-blue and the FEULGEN nuclear staining microtechnique procedures. Vital observations were carried out to establish the nutrition of the Ciliata species. A BÜRKER chamber was used to examine the numbers of individuals in order to determine the frequencies of the individual species.

Considerable help is provided towards the biological study of the effects of town waste-waters by the data of water-chemical examinations. Unfortunately, water-chemical analyses relating to the industrial pollution from the individual factories have not yet been carried out. Chemical analytical data for the samples taken in 1962 above and below Szolnok and at Vezseny were provided by the Central Tisza Regional Water Board. Further, data were also available as published by the Water Division of the National Public Health Institute, relating to water-chemical analyses for the water above and below the mouth of the Zagyva and below the main town sewer inlet (PAPP 1961). The results of examinations carried out over the 10-year period are used to determine the minimum, average and maximum values.

Development of Ciliata plankton

The air temperature at the time of the examinations was 26—30 °C in 1958 and 1970, and 32 °C in 1962. On all occasions the weather was sunny. The water temperature was 18—22 °C in 1958, 23 °C in 1962, and 21 °C in 1970. The pH of the water was 7.4, 7.6 and 7.8. The height of the water was 166.

In the course of the examinations, only those species were taken into consideration which were present on at least 2 occasions in the examination periods. Species occurring on only 1 occasion and as only a few individuals were not taken into account. The species comprising the Ciliata plankton and the frequencies of the individual species are reported in Tables 1 and 2. The categories used to record the frequencies are as follows: 1 = 1—20 specimens (few); 2 = 20—50 individuals (appreciable); 3 = 50—100 individuals (many). The numbers of individuals refer to 100 litres of filtered water.

1. At 340 river km above the town the Ciliata plankton is very poor as regards the numbers of both species and individuals. Of the 4 Ciliata species observed, *Cinetochilum margaritaceum occurs* uniformly from the catharobe in waters of a polysaprobe nature. Chilodonella fluviatilis was found in clear-water sections of the Tisza (JÓSA 1962). A large degree of adaptation to the water saprobia conditions is also exhibited in the Hungarian section of the Tisza by *Cyclidium glaucoma* and *C. obliquum* (JÓSA 1962, 1963, 1964). In the bacterium-poor water, however, both species occur only in low numbers of individuals. The saprobia-endurance of the species and their low numbers of individuals point to unpolluted, clean water.

On the basis of the water-chemical examinations, the water of the Tisza arriving at Szolnok can be classified as of water-quality I above the town. The average number

Table 1. *Development of the Ciliata plankton in the Szolnok bed-section of the Tisza in 1958 and 1970*

	Water-sampling sites																	
	340 r. km		Zagyva mouth above			below	333 r. km		332 r. km		330 r. km		327 r. km		314 r. km	
Trachelophyllum pusillum PERTHY – CLAP L.							2	2			1	1	–	2	–	2
Coleps hirtus NITZSCH			1	2	–	1	2	3			2	3	–	2	–	2
Chilodontopsis depressa PERTHY							–	2	2	–	2	2	1	–	2	–
Chilodontopsis vorax STOKES									3	2	2	–	2	2	2	3
Chilodonella capucina PENARD			2	3			–	2			2	2	2	2		
Chilodonella cucullulus O. F. MÜLLER			–	2			2	–	2	3						
Chilodonella fluviatilis STOKES	1	1														
Frontonia elliptica BEARDSLEY							–	2	3	2	1	–	–	1	2	2
Tetrahymena pyriformis EHRBG.							3	2			2	2				
Colpidium campylum STOKES			–	3			3	3	–	2	3	2	–	2	–	1
Colpidium colpoda STEIN			3	2			3	3	–	2	3	3	–	2	–	2
Cinetochilum margaritaceum PERTY	2	2	–	2			2	2	2	2	1	2	–	2	2	3
Lembus pusillus QUENNERSTEDT									–	2			2	–		
Cyclidium citrullus COHN			3	2			3	2			2	2				
Cyclidium glaucoma O. F. MÜLLER	2	1	3	3	2	–	3	2			2	2	–	2	2	2
Cyclidium obliquum KAHL	2	–					2	–	1	2	2	1	1	2	2	2
Cristigera setosa KAHL			–	2			2	3			2	3	2	3		
Halteria grandinella O. F. MÜLLER			2	2			–	2			2	2				
Blepharisma lateritium LEPSI							2	2								
Holosticha simplicis WANG – NIE			1	—	1	1									2	–
Stylonychia mytilus EHRBG.			–	2			2	3	3	2	2	2	–	2	1	2
Stylonychia pustulata EHRBG.			3	2			2	2	3	2	–	2				
Opisthotricha parallela ENG.			2	2							2	–				
Onychodromus grandis STEIN							2	2	3	2	–	1	–	2	2	2
Euplotes rotunda GELEI							2	1	–	2	–	1				
Aspidisca costata DUJARDIN			1	2			2	2	2	2	2	2			2	2
Vorticella convallaria LINNE – NOLAND			–	2			–	2					3	2	2	2
Number of species in 1958	4		10		2		17		10		18		7		11	
in 1970		3		15		2		20		13		18		14		13

of coli does not reach 10 per ml. A coli number below 10 in the case of surface waters means clean water. The mean value of the oxygen consumption is 4—6, and its maximum is 8—9 mg/l. The average value of BOI_5 (the biological oxygen-demand) is only 2 mg/l, while its maximum does not attain 4 mg/l either. The oxygen saturation in flowing waters classified as clean is 80—90%. In this section of the Tisza the average value of the oxygen saturation is 80% and its maximum is 100%. From a comparison of the data, it can be stated that the results of the water-chemical examinations confirm those of the biological examinations.

2. Directly above the mouth of the Zagyva up to 335 river km, the right bank of the Tisza is visibly polluted. In this section the Tisza flows through the town area. On the right bank 8000 m^3 of domestic waste-water flows daily into the Tisza from the Schefcsik settlement, together with waste-water from the Fishing Cooperative. On the left side the water of the Tisza is polluted from the town strand and the free strand. The number of Ciliata species in the water samples was 10 in 1958 and 14 in 1970. 70% of the species are bacteriophages. The appearance of a larger number of individuals of *Colpidium colpoda*, a poly and α-mesosaprobe indicator organism (KOLKWITZ 1950), demonstrates the richness of bacteria in the

Table 2. *Development of the Ciliata plankton in the Szolnok bed-section of the Tisza in 1962*

	Water-sampling sites							
	340 r. km	Zagyva mouth above	Zagyva mouth below	333 r. km	332 r. km	330 r. km	327 r. km	314 r. km
Lagynophrya halophila KAHL		2						
Coleps hirtus NITZSCH		2	1	2		2	1	
Chilodontopsis depressa PERTY			2			1		3
Chilodontopsis vorax STOKES						1	1	
Chilodonella capucina PENARD		2	1	1				
Colpidium campylum STOKES				2	2	1	1	
Colpidium colpoda STEIN				3		2		
Cinetochilum margaritaceum PERTY				3	2	2	2	
Loxocephalus ellipticus KAHL				2				2
Uronema elegans MAUPAS		2		2				
Lemboides rostrata KAHL				2	1			2
Cyclidium citrullus COHN		2		1				1
Cyclidium glaucoma O. F. MÜLLER		2	1				1	1
Cyclidium obliquum KAHL	1			2		1		
Cristigera setosa KAHL	1	2		2		2	2	
Halteria grandinella O. F. MÜLLER		2						
Stylonychia mytilus EHRBG.				2				1
Stylonychia pustulata EHRBG.		1			2	1		1
Euplotes rotunda GELEI					2			
Aspidisca costata DUJARDIN		2		1	1			
Number of species	2	10	4	13	6	9	6	7

water along the bank. Bacterial pollution is similarly indicated by the occurrence of Cyclidium citrullus, C. glaucoma and Stylonychia pustulata. The bulk of the species are α-mesosaprobe species. The populous species on the left bank (α-meso and polysaprobe) are *Claucoma scintillans, Colpidium campylum, C. colpoda* and Cyclidium citrullus.

It is clear from the data that the water of the Tisza directly above the mouth of the Zagyva exhibits bacterial and organic pollution.

3. As a result of the pollution above the mouth of the Zagyva and the contaminating effect to be expected from the tributary, it was assumed that rich and populous Ciliata plankton would be found below the mouth of the Zagyva. In fact, however, the examinations led to just the opposite result. In each of the 3 years only a few individuals from 1—2 species were found in samples taken below the confluence and 200 m downstream from the bridge.

Examinations below the mouth showed the average value of the coli number to be 30—40, while its maximum value exceeded 100 per ml. On the basis of the number of coli it would be justified to expect a more extensive spreading of the bacteriphage Ciliata species in this section of the river. Since Ciliata plankton fairly rich in bacteriophage species arrive in this bacterium-rich section of the river below the confluence, the disappearance of the Ciliata plankton in this region of the river is particularly striking. The explanation for the disappearance of the population is the chemical state of the tributary.

The data from examinations carried out below the mouth of the Zagyva are as follows: average oxygen-consumption 4 mg/l, maximum oxygen-consumption 12 mg/l, average BOI_5 value 6 mg/l. This means a water quality of grade II. Compared to the section above the mouth, the sulphate contamination is 100 mg/l higher,

at 170 mg/l. The average and maximum values of the total dissolved solid constituent contents of the Tisza water above the mouth of the Zagyva are 100—200 and 200—400 mg/l, respectively, and below the mouth 200—300 and 300—600 mg/l, respectively. The total dissolved solid constituent content of the Tisza water below the mouth of the Zagyva is thus 200 mg/l on average more than above the mouth. This means that the osmotic value of the water of the main river changes essentially after the confluence with the tributary. The concentration change of as high as 50% can result in the destruction of the Ciliata plankton. The ciliated unicellular animals are very sensitive to the osmotic conditions and to fluctuations in the salt concentration of the water.

In the collection periods the water of the Zagyva was dirty, and a dark oil-green in colour. The water-bloom was caused by *Microcystis* and *Anabaena* species. Only a few individuals of 2—3 Ciliata species were found in water samples taken from the Zagyva.

4. The main sewer from the town discharges into the river at 333.7 km, in the vicinity of the Áron Gábor ship-yard. A Ciliata population consisting of 17—20 species was found in samples taken from the detritus-rich water at 333 river km (Table 1). One third of the Ciliata taxons occurring are α-meso and polysaprobe species. Only the bacteriophage species multiplied in the Ciliata plankton. The higher number of *Colpidium colpoda* individuals, a poly and α-mesosaprobe indicator organism, similarly shows that the water of the Tisza became of an α-mesosaprobe nature in this section.

The average number of coli was 40, and its maximum value was 200 individuals per litre. The sulphate contamination was reduced to 70 mg/l. The total dissolved solid constituent content of the river water was the same as the value below the mouth. The average BOI_5 value was 4, and its maximum was 8 mg/l. This means a water quality of grade III. The average value of the oxygen consumption was 4, and its maximum value was 14—15 mg/l. The values of the coli number, the oxygen consumption and the biochemical oxygen demand indicate the state of pollution of the river. The main sewer of the town delivers daily a total of 20,000 m^3 of waste-water into the river.

5. At 332.1 river km the waste-water from the Szolnok Paper and Cellulose Works enters the river, again in a daily quantity of 20,000 m^3. 100 m lover, 500 m^3 of effluent enters the river daily from the sewer of the abattoir. There is no purification plant in either of these works. Below the waste-water inlet from the cellulose factory the surface of the Tisza is covered by a yellowish, dirty, frothy scum. The number of Ciliata species in the water samples here is reduced to 10—12. The individuals of *Chilodontopsis depressa, Ch. vorax, Frontonia elliptica* and *Chilodonella cucullulus* fed here mainly on silicious algae. As a consequence of the pollution from the cellulose factory, therefore, a change occurs in the feeding conditions of the Ciliata plankton and, as a result, in the composition of the species too. The individuals of *Stylonychia mytilus*, otherwise a detritus and bacterium-eating species, were observed in these examinations to be feeding on diatoms too. Of the 10 Ciliata species found in the water samples, therefore, exactly half were species feeding on diatoms. Bacteriophage species were *Cinetochilum margaritaceum, Cyclidium obliquum* and *Aspidisca costata*. There was one predatory species: Onychodromus grandis. One species consumed detritus. The effect of the industrial pollution can be seen in the fact that, as a result of the frothy scum, the Ciliata plankton is relatively rich in the middle of the river too.

6. At 331.2 river km the waste-water from the hospital is discharged into the

river (500 m^3 per day). Opposite the hospital waste-water inlet is that from the Tiszaliget holiday-camp. At 331 river km 25,000 m^3 waste-water enters the river daily from the sugar factory. A comparatively high number of Ciliata plankton species were found in water samples taken at 330 river km. The dirty, frothy scum on the surface of the river forms huge patches and islands, 2—3 cm in thickness. These scum-islands are not dispersed even after floating for long distances downstream. 60% of the Ciliata plankton are bacteriophages, and 4 species consume detritus. 5 of the species are α-meso and polysaprobe species. Of these, *Colpidium campylum* and *Colpidium colpoda* occurred in appreciable numbers of individuals in the water samples. The number of individuals in the species is less than in the population arriving from upstream. The species composition of the Ciliata plankton is indicative of α-mesosaprobe water. Compared to the degree of saprobia of the water, the density of the individuals in the species is relatively low, i.e. they are rare. The low Ciliata plankton population indicates chemical pollution which has a harmful effect on Ciliata plankton, and may even be toxic.

7. At 328 river km the effluent from the chemical works is discharged into the Tisza. This comprises 40,000 m^3 daily. Water samples were taken at 327 river km. The data from the examinations in 1958 and 1962 show that below the inlet from the chemical factory the Ciliata plankton in the river is diminished considerably as regards the numbers of both species and individuals. The Ciliata population is decreased to 7 species, 2 of which consume diatoms. *Vorticella convallaria* occurred in appreciable numbers only among the detritus. The diminishing of the Ciliata plankton was obviously caused by the sulphurous acid contamination. Richer Ciliata populations were found in the water samples taken in 1970. The plankton then consisted of 14 species, the bulk of these containing appreciable numbers of individuals. The cause of the change is that a neutralizing plant was installed to control the effluent from the chemical works in 1963.

8. 11—13 Ciliata species can be found in water samples taken at 314 river km below the town. The majority of these are β-mesosaprobe species. The self-purification of the river water is confirmed by the values of the oxygen saturation and BOI_5. At Vezseny these are 84—95% and 2.23—3.52 mg/l, respectively.

The salt concentration of the water of the Tisza at Vezseny is variable: the total dry-matter content fluctuates between 293 and 562 mg/l. The effects of the pollution from the cellulose and sugar factories can still observed in water samples taken at Vezseny.

Saprobiological analysis of the Ciliata plankton

The development of the number of Ciliata plankton species is depicted graphically in Fig. 2. If the development of the numbers of these species is compared with examinations of the plankton algae made in the Szolnok bed-section of the Tisza in 1960 and 1961 (UHERKOVICH 1962), it can be concluded that the microphytoplankton and the microzooplankton react in different ways to the effects of pollutants. The unpolluted river water provides ecological conditions favourable for the spreading of the plankton algae. Whereas the algal vegetation is rich in the pure river water, the reason for the very low Ciliata plankton population is to be found just in the purity of the river water. The bulk of the Ciliata species living in the Tisza are bacteriophages. It is natural, therefore, that the Ciliata species will appear and spread at those sites in the river where, because of the organic pollution, the

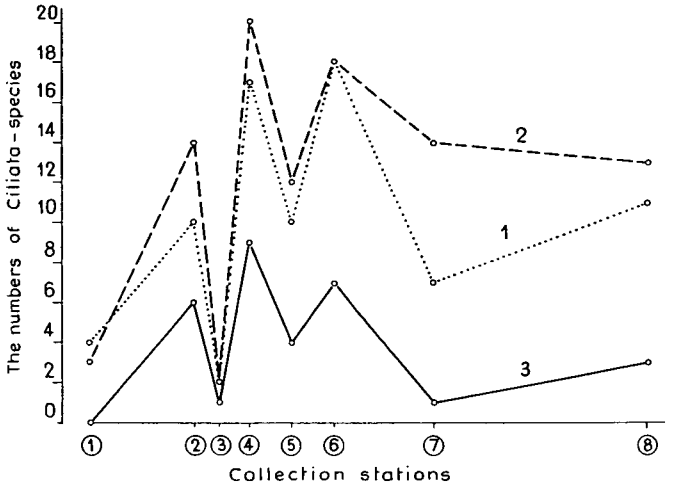

Fig. 2. Development of the numbers of Ciliata plankton species.
1 = results of study in 1958
2 = results of study in 1970
3 = α-meso and polysaprobe species

bacterial flora becomes rich and populous. The results of plankton examinations show that on the action of the town waste-waters the number of Ciliata plankton species is always higher, if other harmful effects do not influence the water of the river, than in unpolluted sections of the river. On the other hand, the town waste-water causes a significant decrease in the number of plankton algae taxons. From a comparison of the taxon numbers the conclusion may be drawn that, in contrast with a decrease in the number of plankton algae individuals, the number of Ciliata plankton species indicates the bacterial pollution of the river water in a positive manner. The increases in the curve depicting the number of species in Fig. 2 show that the number of Ciliata plankton species rises on the effect of the pollution from the town (at 335, 333 and 330 river km).

The development of the relations concerning the number of Ciliata plankton individuals, given in terms of the frequencies, is illustrated graphically in Figures 3 and 4. If the densities of the individuals of the species in each population are compared

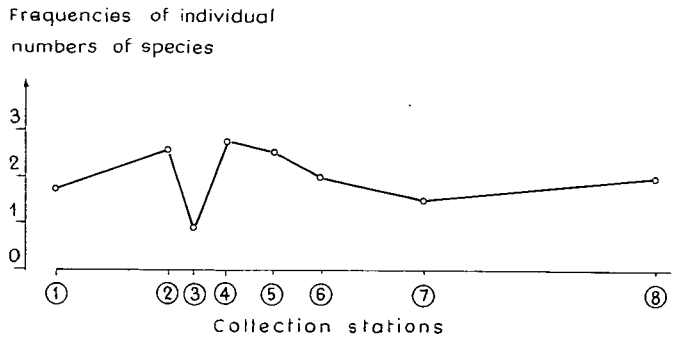

Fig. 3. Frequencies of Ciliata plankton species.

to the degree of saprobity of the biotope concerned, then it becomes clear that the number of individuals in the species is relatively low. The data of a number of foreign authors (BICK, WILBERT, etc.) and the investigations in the Danube by MAGDA BERECZKY indicate that with the increase of the temperature of the water there is a parallel tendency to decrease in the numbers of both the species and the individuals. A contribution towards the reduction of the species is also made by deleterious pollution of the river water. The comparatively low numbers of individuals in the species living in the Ciliata coenoses of the polluted bank sections draw attention to the fact that the chemical effects of the industrial pollutants can be toxic as regards the life in the water of the river.

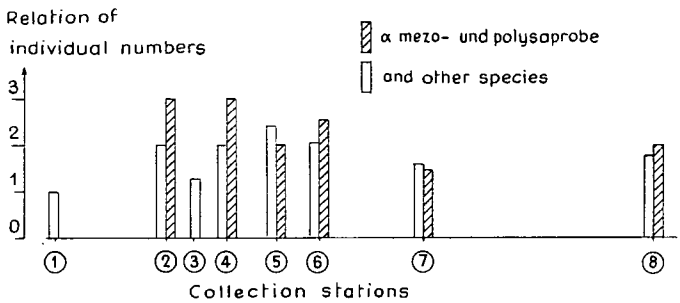

Fig. 4. Comparative graph showing frequencies of α-meso and polysaprobe, and other species at the collection sites.

According to water-chemical examinations, the water of the Tisza above Szolnok, below the main sewer of the town, and below the cellulose factory can be classified as of grades I, II and III, respectively. On the basis of the indicator organisms of the plankton algae associations, UHERKOVICH classifies the bank-side water below the cellulose, sugar and chemical works as of an α-mesosaprobe nature.

In order to be able to demonstrate the degree to which the town effluents affect the saprobe character of the bank-side water, saprobiological analysis of the members of the plankton is necessary. In the characterization of the saprobiological degree of the Ciliata species the findings of KOLKWITZ (1950) were given preference.

Of the Ciliata species, Colpidium colpoda is a species classified as an indicator organism (KOLKWITZ 1950). As a poly and α-mesosaprobe indicator organism, *Colpidium colpoda* appears and multiplies only in the polluted bank-side waters. Such areas are to be found in the Szolnok reaches of the Tisza in the section above the mouth of the Zagyva, and the sections below the inlets from the main sewer of the town and from the sugar factory. As a polysaprobe organism, Tetrahymena pyriformis similarly indicates the degree of pollution of the water. Based on the data of SLADECEK (1973) and other authors, this can also be regarded as an isosaprobe species. As a consequence of the pollution from the town, the following poly and α-mesosaprobe Ciliata species also appear among the Ciliata plankton of the Tisza: *Chilodonella cucullulus, Colpidium camylum, Cyclidium citrullus* and *Stylonychia pustulata*. The appearances of the α-meso and polysaprobe Ciliata species indicate that on the action of the waste-water from the main sewer of the town, the effluent of the sugar factory, and the contamination above the mouth of the Zagyva, the right and left banks of the Tisza become of an α-mesosaprobe character.

From an analysis of the species compositions of the individual Ciliata populations it can be stated that in these bank-side waters which have assumed an α-mesosaprobe character large numbers of β-mesosaprobe species also appear in addition to the α-meso and polysaprobe species. The author's saprobiological examinations in the Szeged reaches of the Tisza similarly confirmed that as a result of the waste-water from the sewers of the inner town and at Boszorkány Island the β-mesosaprobe Ciliata species too appeared en masse in the water which had become of α-meso and even polysaprobe nature (JÓSA 1963).

Cinetochilum margaritaceum, Cyclidium glaucoma, Cyclidium obliquum and *Aspidisca costata* can be found at most of the collection sites. These are widespread species in the bed-section at Szolnok. They never multiply en masse, however, in parts of the bed-section with different saprobities. The widespread species are in general eurisaprobe species, such as *Cinetochilum margaritaceum*, for example. According to the investigations of LIEBMANN (1964), *Aspidisca costata* appears where the degree of β-mesosaprobity of the water undergoes a transition to the α-mesosaprobe grade.

The microfauna of the water of the Tisza at Szolnok was also studied by GÁL (1963) in June 1962. In that period he did not find Ciliata species in the plankton above Szolnok, while its frequency below the town was practically insignificant.

Comparison of the Ciliata plankton with the Ciliata fauna of other biotopes

In addition to the Ciliata plankton, a study was also made of the Ciliata fauna living in algal coatings on bank-side stones, jetties and boats and in decaying matter floating in the river Tisza in its reaches at Szolnok. Only a few data are reported from this study, in the interest of comparison.

In an algal coating sample taken from the jetty of the boat-station at 333 river km, there was a Ciliata fauna rich in both species and numbers of individuals. The species-composition of this population was as follows: *Trachelophyllum pusillum* PERTY-CLAP. L., *Coleps hirtus* NITZSCH, *Hemiophrys fusidens* KAHL, *Loxophyllum helus* STOKES, *Lionotus fasciola* EHRBG.—WRZESENIOWSKI, *Chilodontopsis vorax* STOKES, *Chilodonella cucullulus* O. F. MÜLLER, *Paramecium caudatum* EHRBG., *Glaucoma scintillans* EHRBG., *Tetrahymena pyriformis* EHRBG., *Colpidium campylum* STOKES, *Colpidium colpoda* STEIN, *Cinetochilum margaritaceum* PERTY, *Uronema marinum* DUJARDIN, *Cyclidium glaucoma* O. F. MÜLLER, *Cyclidium obliquum* KAHL, *Cristigera setosa* KAHL, *Metopus fuscus* KAHL, *Metopus mucicula* KAHL, *Halteria grandinella* O. F. MÜLLER, *Onychodromus grandis* STEIN, *Euplotes charon* MÜLLER and *Vorticella convallaria* LINNÉ—NOLAND.

In scrapings taken from the surfaces of decaying matter and pieces of bark washed to the bank at 307 river km the Ciliata populations were very rich both in species and in numbers of individuals. The species occurring en masse were: *Paramecium caudatum* EHRBG., *Colpidium campylum* STOKES, *Tetrahymena pyriformis* EHRBG., *Glaucoma scintillans* EHRBG., *Cyclidium glaucoma* O. F. MÜLLER, *Cyclidium obliquum* KAHL, *Lembus subulatus* KENT, *Metopus fastigatus* KAHL Species occurring in appreciable numbers of individuals were: *Trachelophyllum pusillum* PERTHY—CLAP. L., *Uronema marinum* DUJARDIN, *Stentor coeruleus* EHRBG., *Oxytricha* sp. and *Euplotes charon* MÜLLER.

In a sample taken from the muddy bank-side water rich in detritus at 340 river

km, besides the many *Amoeba Cinetochilum margaritaceum* PERTY and *Cyclidium obliquum* KAHL were found with many individuals, and *Glaucoma scintillans* EHRBG., *Tetrahymena pyriformis* EHRBG., *Cristigera setosa* KAHL, *Metotopus fuscus* KAHL and *Euplotes patella* MÜLLER with appreciable numbers of individuals.

It is clear from a taxonomic analysis of the Ciliata fauna of the different biotopes that the Ciliata fauna living in the bank-side mud, in the algal coatings and on the decaying matter is richer than the Ciliata plankton. The Ciliata species find favourable feeding conditions in the bank-side mud of the unpolluted river-water at 340 river km, and in the water of a sapropel nature, and accordingly they multiply there. The β- and α-mesosaprobe species multiply en masse in the algal coatings at the inlet of the main sewer of the town. Rich and populous Ciliata populations can be found on the decaying matter washed to the bank below the effluent inlet from the chemical works. Here too the species include more poly and α-mesosaprobe Ciliata species. Populous Ciliata coenoses rich in numbers of species can similarly be found in the algal coatings on the sides of boats. Examinations of the various biotopes confirm that the main habitats of the Ciliata fauna in the Tisza consist of decaying matter, and the coatings on bank-side stones, jetties and boats. The population densities of these biotopes also show that these biotopes provide protection to the Ciliata plankton against the harmful action of pollutants.

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